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(71) Applicant(s)
United Microelectronics, Corp.
(Incorporated in Taiwan)
No.3, Li-Hsin Road II, Science-Based Industrial Park, Hsinchu, Taiwan

(72) Inventor(s)
Hsueh-Chung Chen

(74) Agent and/or Address for Service
Edward Evans & Co
Clifford's Inn, Fetter Lane, LONDON, EC4A 1BX, United Kingdom

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(54) Abstract Title
Lifetime self-indicated polishing pad.

(57) The polishing pad has a main body (21) and a colored indicating structure (22) a certain distance under the surface (23). While performing chemical mechanical polishing, a slurry is supplied onto the polishing pad to react with the water to be polished. As the polishing pad is consumed until, when reaching the colored indicating structure, a different color appears on the pad to indicate the consumption level. The color can be further changed with consumption to show the lifetime of the pad. Thus the quality of products being polished is very much enhanced, and the fabrication cost is reduced since the risk of polishing wafers by a worn out pad is prevented.

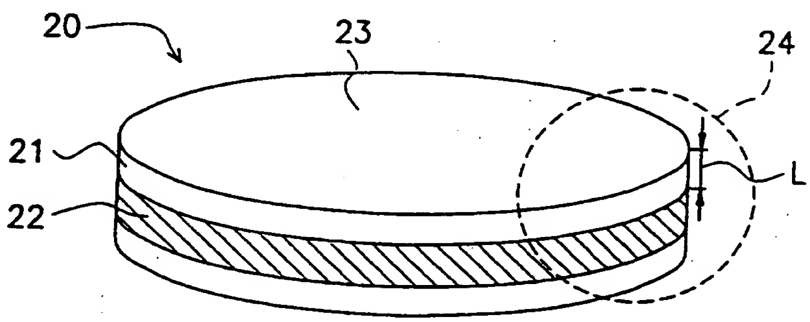

FIG. 2A

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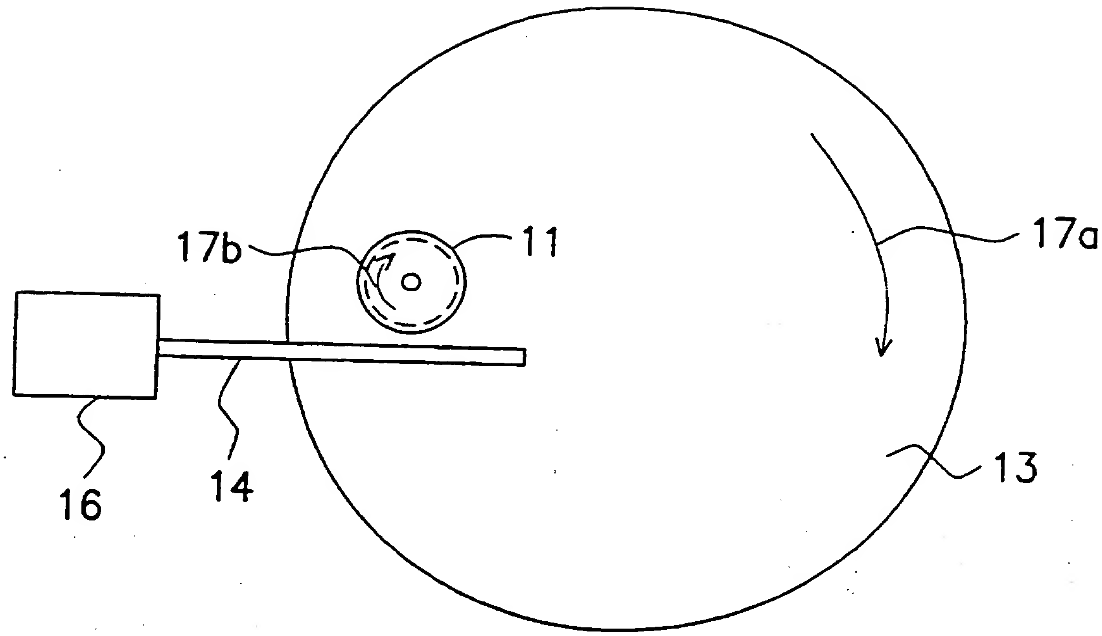

FIG. 1A (PRIOR ART)

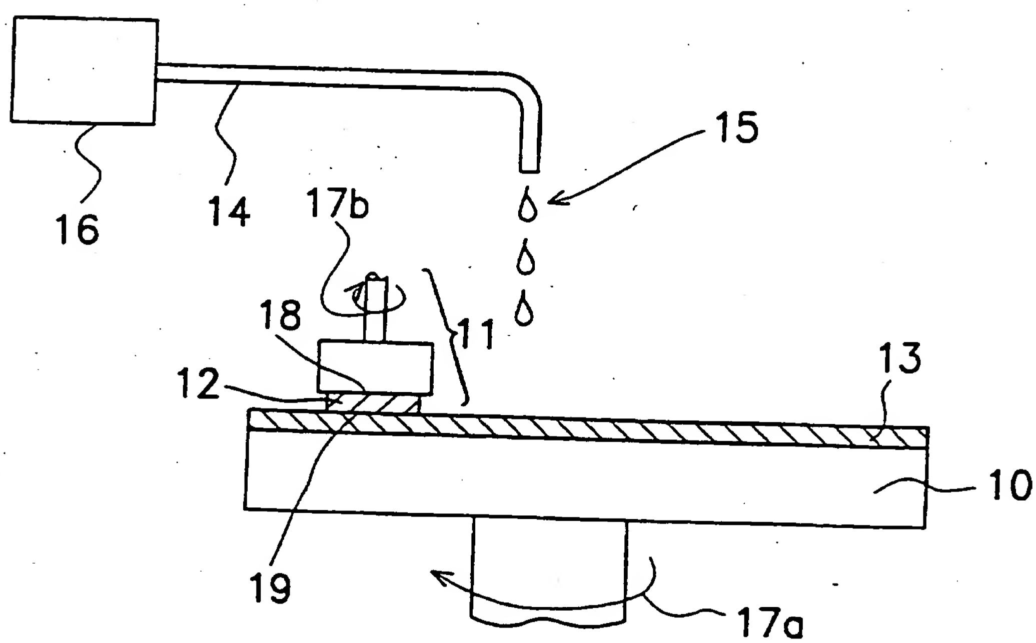

FIG. 1B (PRIOR ART)

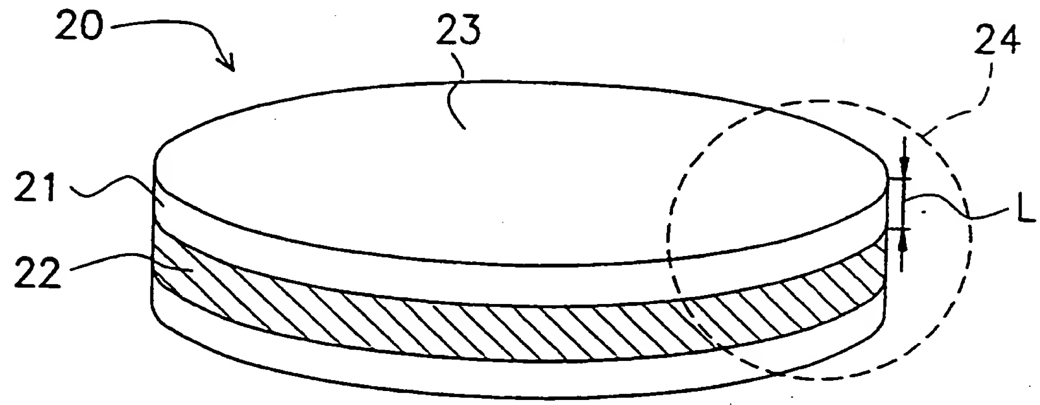

FIG. 2A

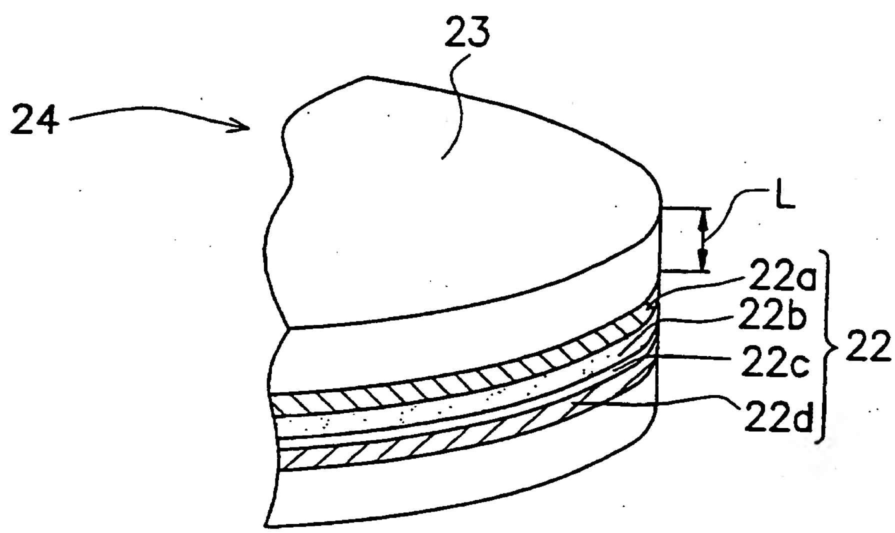

FIG. 2B

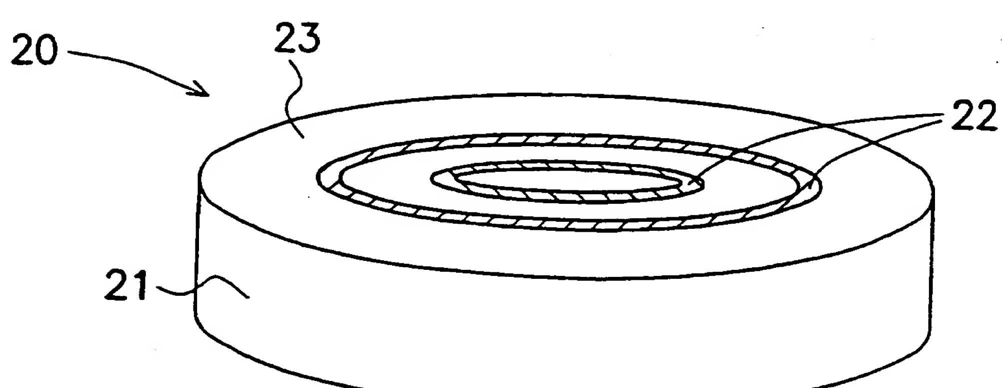

FIG. 2C

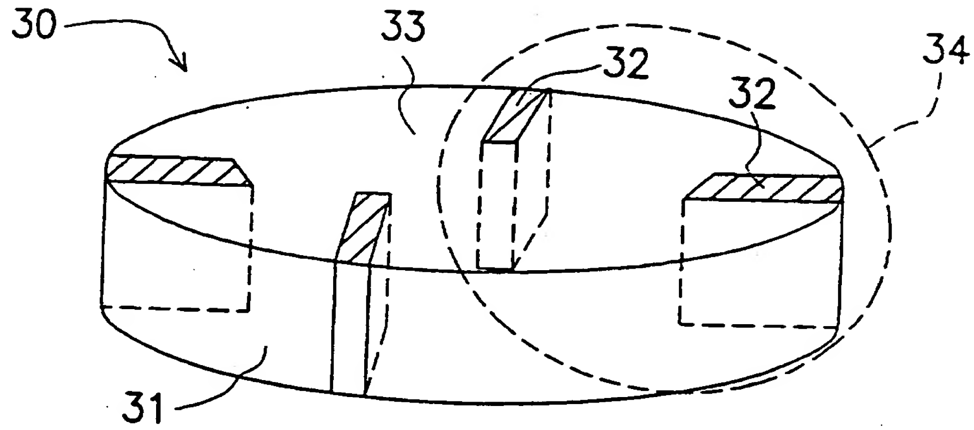

FIG. 3A

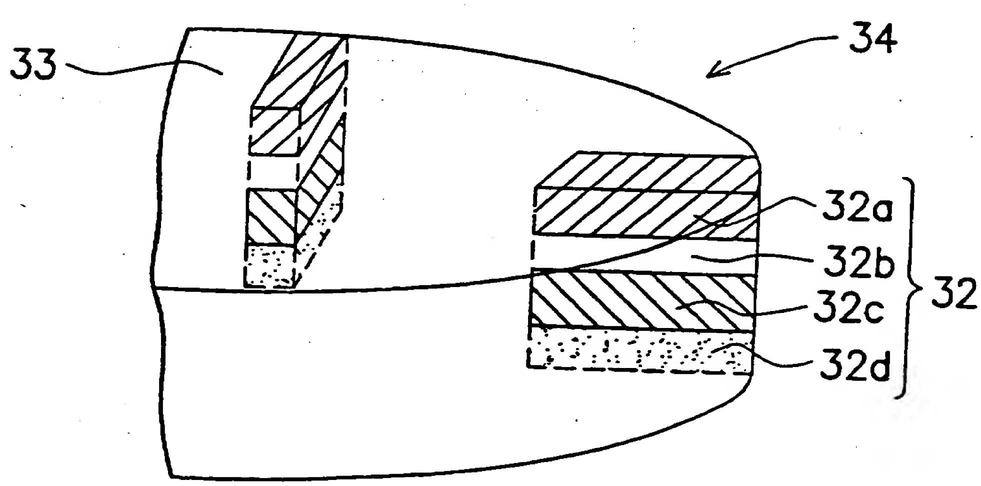

FIG. 3B

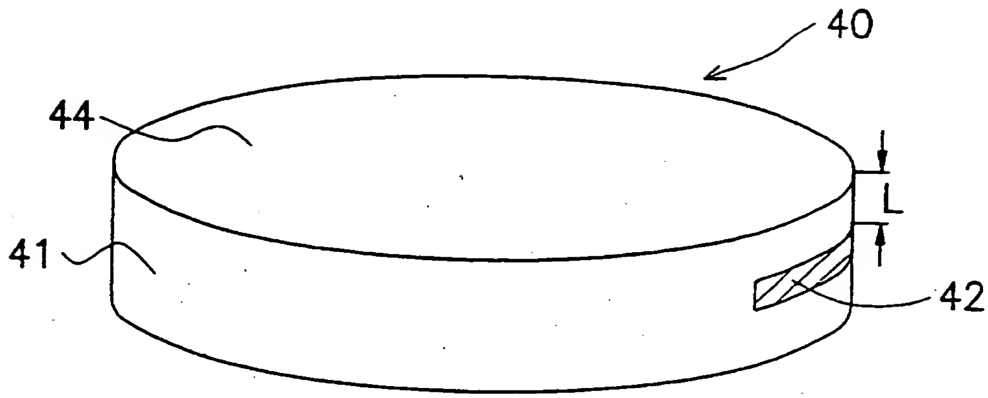

FIG. 4

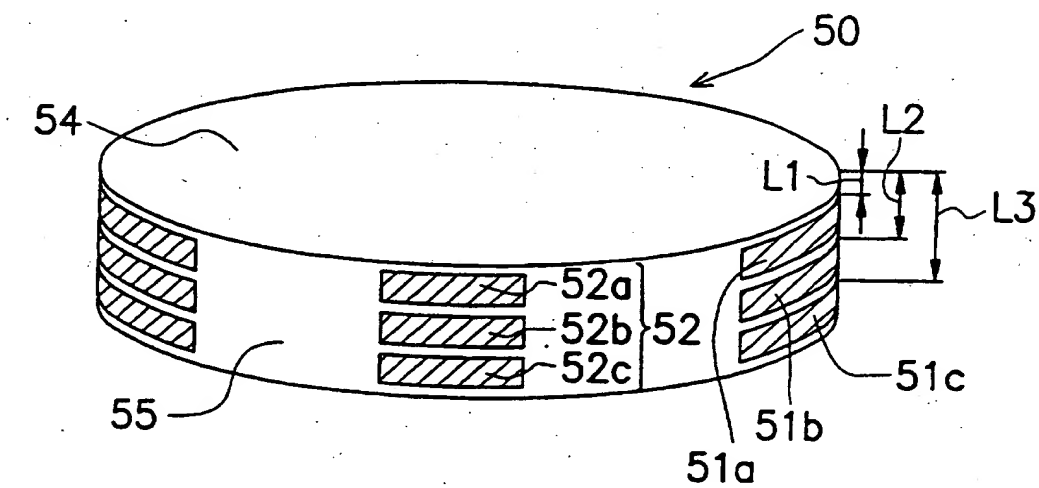

FIG. 5

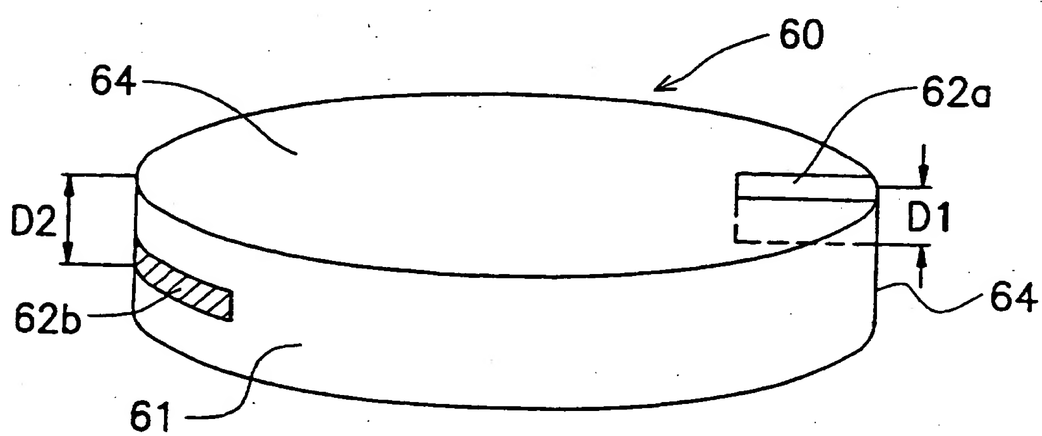

FIG. 6

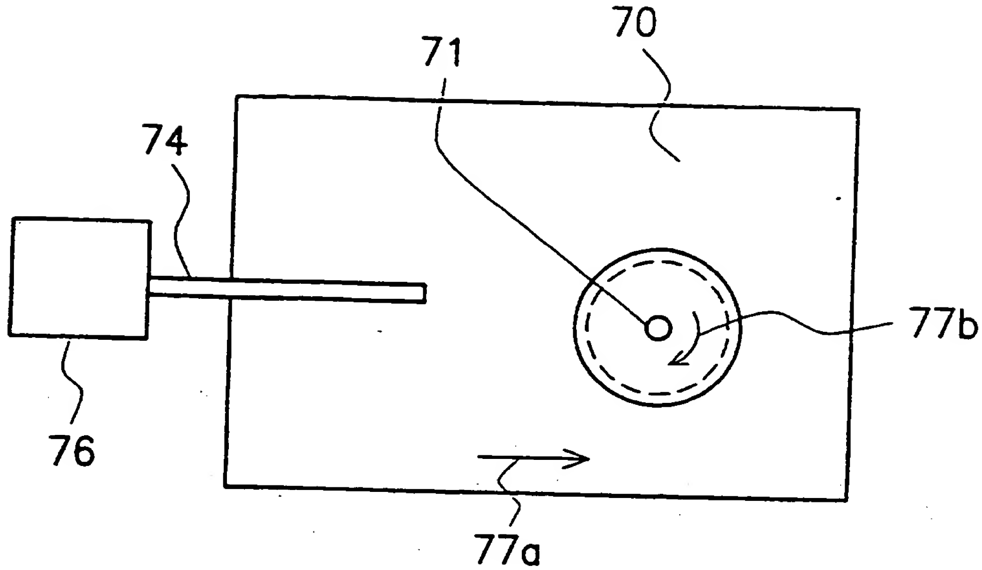

FIG. 7A

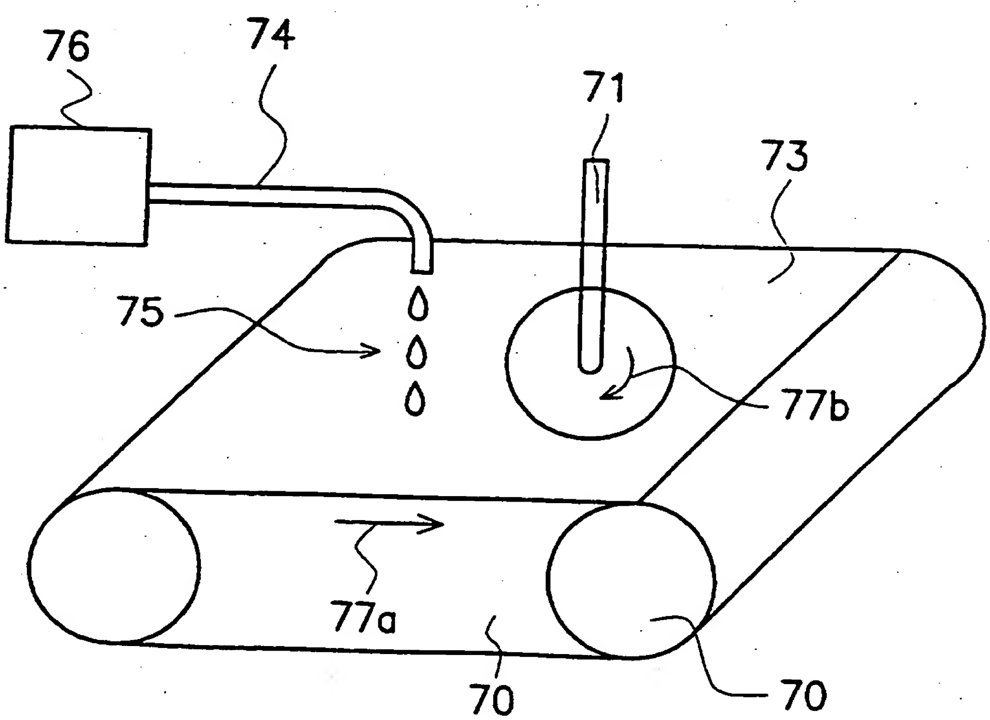

FIG. 7B

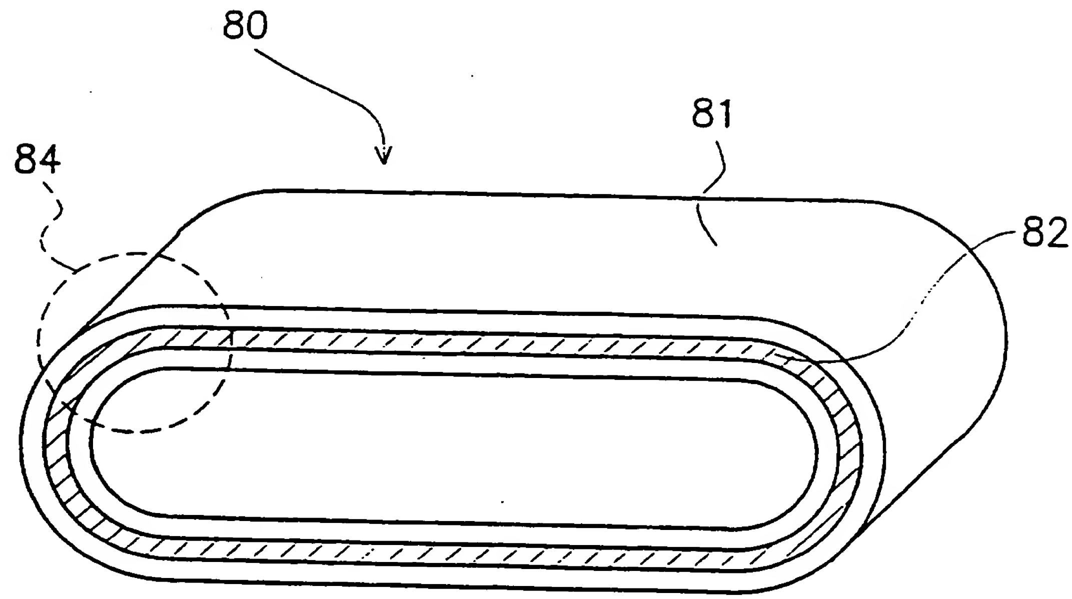

FIG. 8A

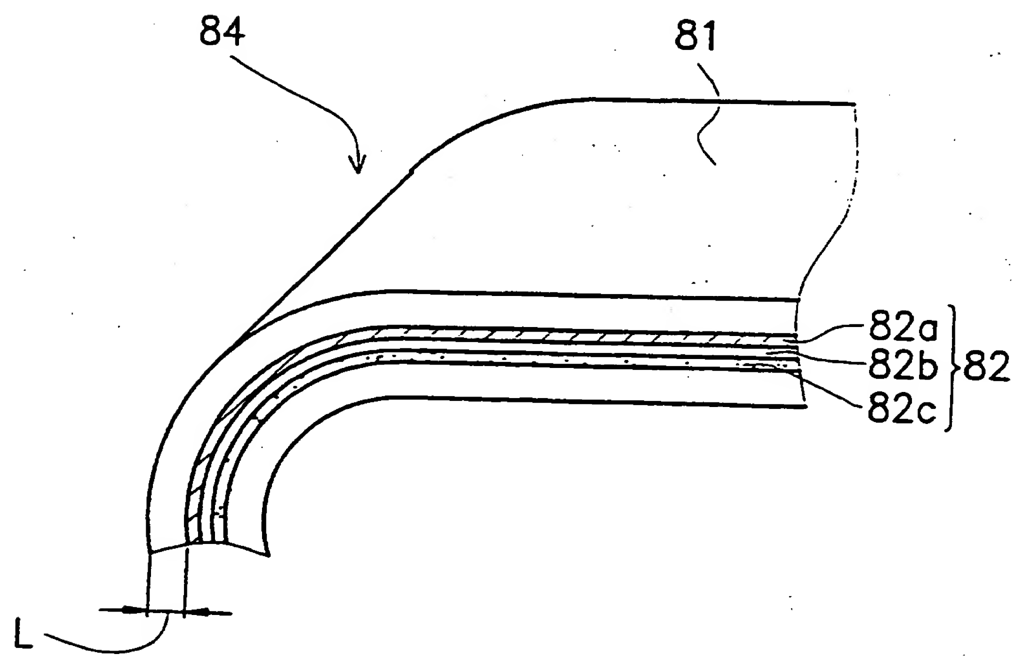

FIG. 8B

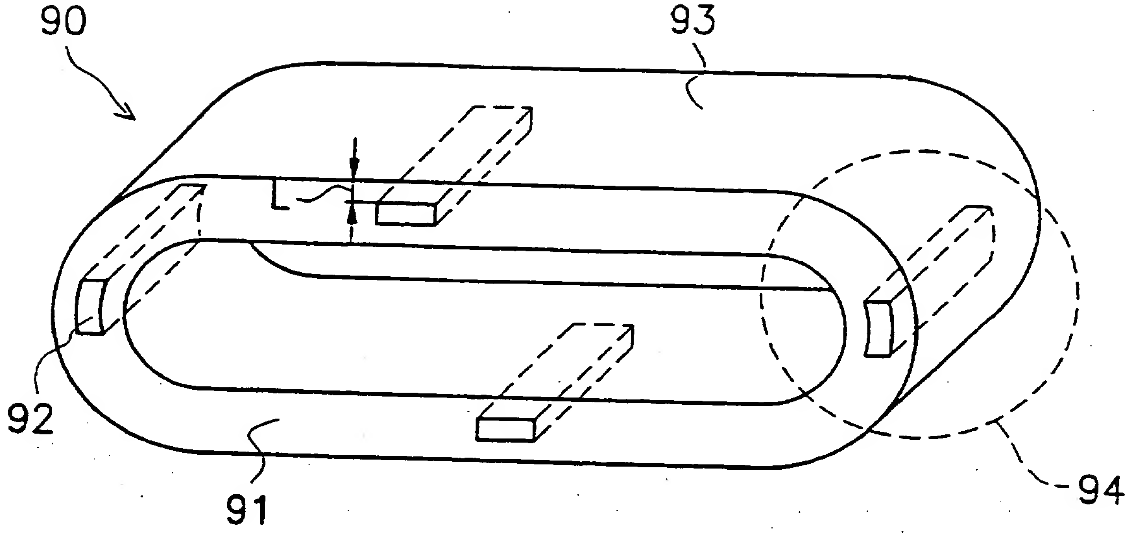

FIG. 9A

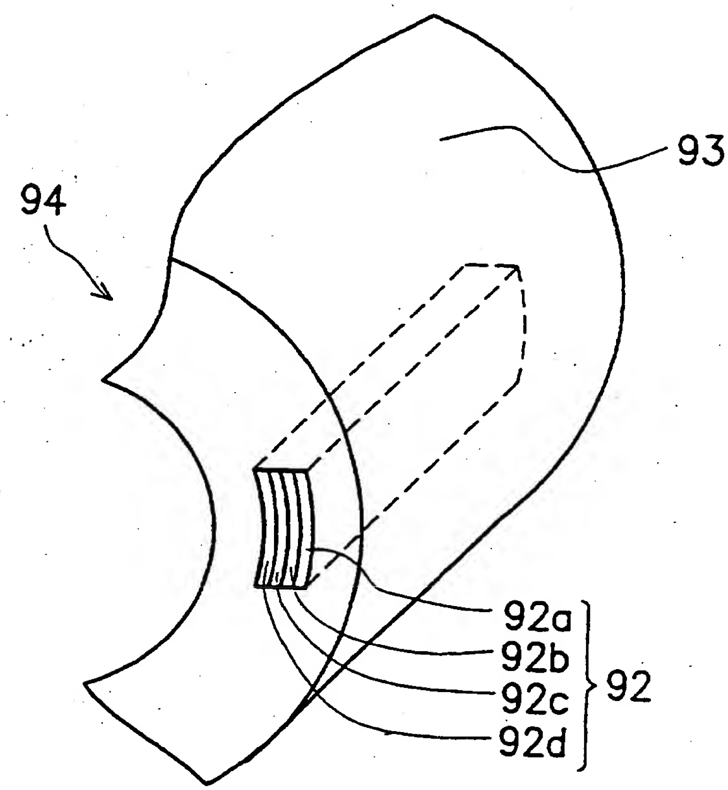

FIG. 9B

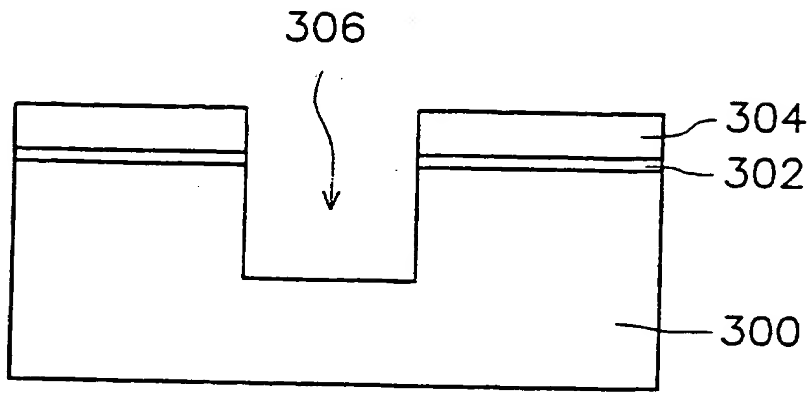

FIG. 10A

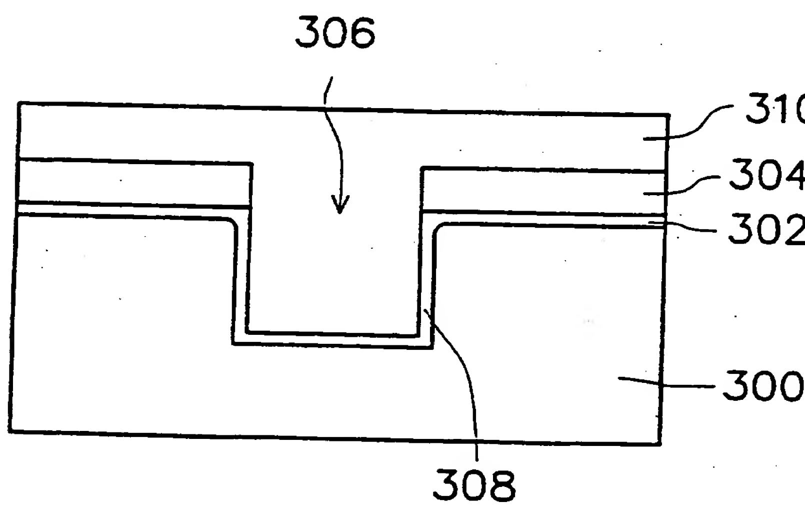

FIG. 10B

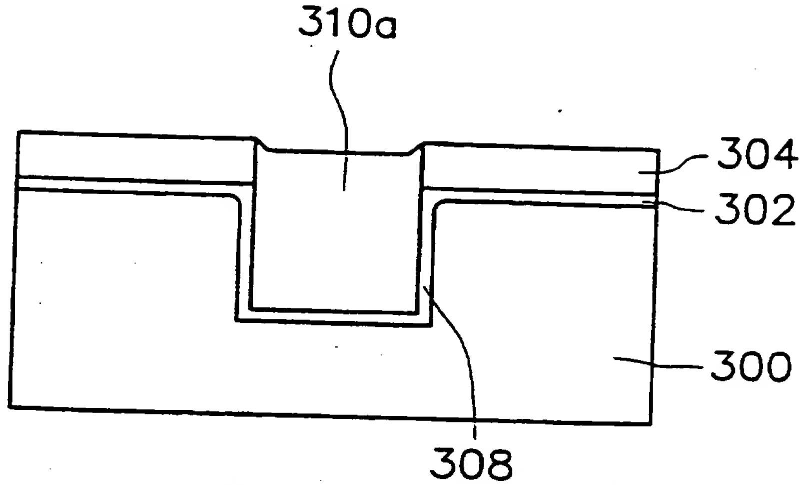

FIG. 10C

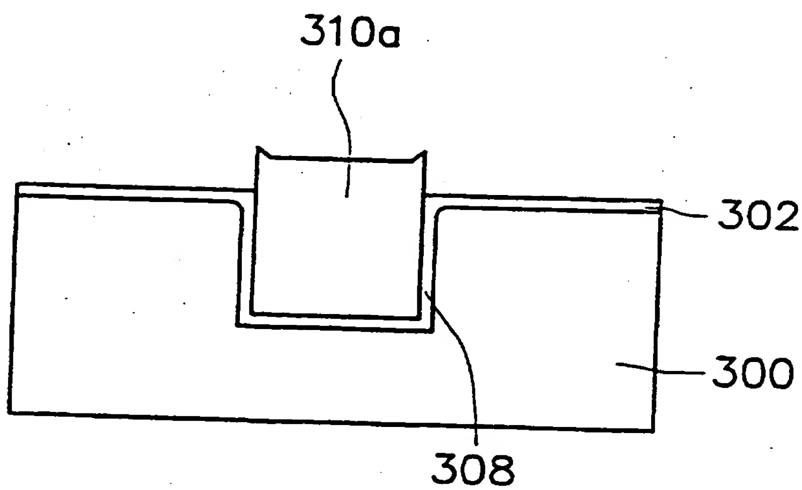

FIG. 10D

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LIFETIME SELF-INDICATED POLISHING PAD

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates in general to a polishing pad of a chemical mechanical polisher, and more particularly, to a polishing pad with a function of lifetime self-indication.

Description of the Related Art

In semiconductor fabrication process, planarization is an important technique for high density photolithography to achieve a precise pattern transfer without scattering during exposure. Two commonly used planarization techniques includes spin-on-glass (SOG) and chemical mechanical polishing (CMP). As the technique of fabrication is developed to a sub-half-micron regime, the technique of SOG can not meet the requirements of planarization. Currently, chemical mechanical polishing becomes the only technique that can achieve global planarization for very large scale integration (VLSI) or even ultra large scale integration (ULSI).

The polishing pad of a chemical mechanical polisher is a consumptive element. In conventional chemical mechanical polishing, the polishing pad is changed after performing hundreds of polishing processes. The lifetime of the polishing pad is difficult to detect since the polishing condition and material can be different for each polishing process. There is no method or equipment to detect whether a polishing pad

is worn out or not so far. Thus. the polishing time is often a parameter to determine the lifetime currently. Another parameter to determine the lifetime is the number of the stacked polishing layers. It is obvious that to determine the lifetime and the consumption level of the polishing pad by both of the above parameters is not precise enough. Unable to precisely detect the lifetime of a polishing pad is disadvantageous to control the quality of products or structures, especially for those structures still under a research stage. In addition. for those wafer equipment original manufactures (OEM), the parameters or conditions for fabrication is varied often. Thus, it is even more difficult to detect the lifetime of a polishing pad.

SUMMARY OF THE INVENTION

The invention to provide a lifetime self-indicated polishing pad. While performing chemical mechanical polishing, the polishing pad indicates the consumption level and the lifetime of itself. Thus, the quality of products being polished is very much enhanced. Moreover, the fabrication cost is reduced since the risk of polishing wafers by a worn out pad is prevented.

To achieve the above-mentioned objects and advantages, a polishing pad is provided. The polishing pad comprises a main body and a colored indicating structure inlaid under a top surface of the main body. The colored indicating structure may further comprise multicolored indicating layers. These indicating layers may be in a dish shape, annulus shape, or strip shape. Alternatively, the colored indicating structure may comprises more than one colored indicating strips, and each of the colored indicating strips may further comprise more than one colored indicating layers.

While performing chemical mechanical polishing. the polishing pad is worn out with the slurry as a consumption part. While the consumption of the polishing pad reaches to a lifetime of the polishing pad. that is. while the polishing pad is substantially worn out, a new polishing pad is installed and replacing the worn out polishing pad. Therefore. the quality of the wafer to be polished is not deteriorated.

Both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A shows a top view of a conventional chemical mechanical polisher;

Figure 1B shows a side view of a chemical mechanical polisher;

Figure 2A shows a side view of a lifetime self-indicated polishing pad in a chemical mechanical polisher according to a first embodiment in the invention;

Figure 2B is a schematic drawing showing a structure of the lifetime self-indicated polishing pad shown in Figure 2A;

Figure 2C is a top view showing another structure of the lifetime self-indicated polishing pad;

Figure 3A shows a side view of a lifetime self-indicated polishing pad in a chemical mechanical polisher according to a second embodiment in the invention;

Figure 3B is a perspective view of the lifetime self-indicated polishing pad shown in Figure 3A;

Figure 4 shows a side view of a lifetime self-indicated polishing pad in a chemical mechanical polisher according to a third embodiment in the invention;

Figure 5 shows a side view of a lifetime self-indicated polishing pad in a chemical mechanical polisher according to a fourth embodiment in the invention;

Figure 6 shows a side view of a lifetime self-indicated polishing pad in a chemical mechanical polisher according to a fifth embodiment in the invention;

Figure 7A and Figure 7B are top and side views showing a chemical mechanical polisher;

Figure 8A shows a side view of a lifetime self-indicated polishing pad in a chemical mechanical polisher according to a sixth embodiment in the invention:

Figure 8B is a perspective view of the lifetime self-indicated polishing pad shown in Figure 8A;

Figure 9A shows a side view of a lifetime self-indicated polishing pad in a chemical mechanical polisher according to a seventh embodiment in the invention;

Figure 9B is a perspective view of the lifetime self-indicated polishing pad shown in Figure 9A; and

Figure 10A to Figure 10D are cross sectional views showing the fabrication process of forming a shallow trench isolation in a preferred embodiment according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in Fig. 1A and Fig. 1B, a chemical mechanical polisher comprises a polishing table 10, a holder 11, a polishing pad 13 disposed on the polishing table 10, a tube 14, and a pump 16. A wafer 12 to be polished is held by the holder 11 above the polishing pad 13. While polishing, a slurry 15 is supplied onto the polishing pad 13

from the tube. The pump 16 is to pump the slurry 15 to the tube 14. During the polishing process, the polishing table 10 and the holder 11 rotate towards certain direction shown as arrows 17a and 17b, respectively. The holder 11 holds the wafer 12 with the surface to be polished, that is, the front surface 19, facing the polishing pad 13, while the other surface, called the rear surface 18 here, is on the other side. The slurry 15 is continuously supplied to the polishing pad 13 via the tube 14 from the pump 16. The mechanism of chemical mechanical polishing is to use the slurry 15 as a chemical reagent to react with the front surface 19 of the wafer 12, so that an easily polished layer is formed. With the aid of abrasive particles contained in the slurry 15, the elevated part of the easily polished surface is thus removed by polishing. Repeating the above mechanism, the wafer is thus polished and planarized as required. Chemical mechanical polishing basically adapts the technique of mechanical polishing with the aid of chemical reaction between the chemical reagent and the polishing particles to achieve planarization.

In Fig. 2A, a side view of a polishing pad is shown. Fig. 2B shows a perspective side view of a part 24 of the polishing pad shown in Fig. 2A. A lifetime self-indicated polishing pad 20 comprises a main body 21 and a multicolored indicating layer 22. The main body 21 is preferably in a dish shape, though the practical shape thereof depends on practical application. The main body 21 has a top surface denoted by the reference numeral 23. The material of the main body 21 and the multi-colored layer 22 is the same. The multi-colored layer 22 is laminated and inlaid inside of the main body 21. The distance between the top surface 23 of the main body 21 and the multi-colored layer 22 is L. The distance L is typically constant and defined as the

consumption level of the polishing pad. The distance L is ranged between about 20 to 500μm. The multi-colored layer 22 further comprises colored layers such as 22a, 22b, 22c, 22d shown as Fig. 2B. These colored layers 22a, 22b, 22c, 22d are in different colors and with different depths. The shapes of the colored layers 22a, 22b, 22c, 22d are not restricted as a dish shape. One or more than one of the colored layers 22a, 22b, 22c, 22d may also be in annulus shape shown as Fig. 2C. The multicolored layers 22 may also replaced by a single colored layer mounted under the top surface 23 with a depth of about 20 to 500μm.

In Fig. 3A, a side view of a polishing pad in another embodiment is shown. Fig. 3B shows a perspective side view of a part 34 of the polishing pad shown in Fig. 3A. A lifetime self-indicated polishing pad 30 comprises a main body 31 and a multicolored indicating layer 32. The main body 31 is preferably in a dish shape, though the practical shape thereof depends on practical application. The main body 31 has a top surface denoted by the reference numeral 33.

While the multicolored layer 32 is much smaller than the radius of the polishing pad 30, the multicolored layer 32 is in a strip shape as shown in the figure. The multicolored layer 32 may comprise more than one strip. The multicolored layer 32 is inset in the main body 31. As shown in the figure, the multicolored layer 32 is laminated and inlaid into the main body 31 under the top surface 33. The multicolored layer 32 is formed by a material the same as or similar to the material of the main body 31. The multicolored layer 32 has a thickness larger than a certain value of thickness. This certain value of thickness is typically smaller than the thickness of the polishing pad 30, for example, between about 20 to 500μm. The certain value of thickness is an

indication for the lifetime of the polishing pad. The multicolored layer 32 may further comprise more than one colored layer such as 32a, 32b, 32c, 32d as shown in Fig. 3B. The color of each colored layer 32a, 32b, 32c, 32c is different from each other. Observing from the top, each of the colored layers 32a, 32b, 32c, 32d is inset in different position of the main body 31. The dispositions of more than one colored layers are to detect the consumption level of lifetime in different area of the polishing pad 30. Therefore, the lifetime of the polishing pad can be indicated more precisely than detecting from a single point.

Fig. 4 shows a side view of another polishing pad in a chemical mechanical polisher. The lifetime self-indicated polishing pad 40 comprises a main body 41 and an indicating colored strip 42. Preferably, the main body 41 is in a dish shape, though the actual shape is determined by specific requirements while performing polishing. The indicating colored strip 42 is embedded inside the main body 41 under a depth L from a top surface 44 of the main body 41. The depth L typically indicates the consumption level after being operated for a lifetime thereof. The depth L is typically ranged from about 20 to 500μm, however, it is to be noted that the actual depth L may be different according to the thickness of the polishing pad 40. The indicating colored strip 42 may be formed by material such oxidation/reduction agent or acid/alkaline test agent that it will react with slurry to indicate the consumption of pad. The indicating colored strip 42 may comprise more than one colored strips (referring to Fig. 6) disposed in a certain depth L under the top surface 44 in different position.

Fig. 5 shows another example of a polishing pad in a chemical mechanical polisher. The polishing pad 50 comprises a main body 55 and a multi-layered

indicating strip structure 51 or 52, or both of 51 and 52. Preferably, the main body 55 is in a dish shape with a top surface 54. The multi-layered indicating strip structure 51 comprises several indicating strips 51a, 51b, 51c or more than three strips as specific requirements under the top surface 54, while the multi-layered structure 52 comprises several indicating strips, for example, 52a, 52b, and 52c. These indicating strips 51a, 51b, 51c or 52a, 52b, 52c display different colors while reacting with slurry, in addition, these indicating strips has different depth under the top surface 54. For example, the indicating strip 51a is disposed under the top surface 54 with a depth L1, the indicating strip 51b is under the top surface 54 with a depth L2, and the indicating strip 51c is under the top surface 54 with a depth L3. The largest depth is smaller than the thickness, for example, 20μm to 500μm, of the main body 55. The indicating strips 51a to 51c or 52a to 52c may be formed by material such oxidation/reduction agent or acid/alkaline test agent.

In Fig. 6, yet another polishing pad of a chemical mechanical polisher is shown. The polishing pad 60 comprises a main body 61 and an indicating strips 62a and 62b. Preferably, the main body 61 is in a dish shape with a top surface 64. The indicating strips 62a and 62b are embedded under the top surface 64 with a depth D1 and D2, respectively. Either depth D1 or D2 is constant. The constant depth is less than the thickness of the main body 61, for example, 20μm to 500μm. The indicating strips 62a and 62b display different colors while reacting with the slurry. The indicating strips 62a and 62b may be formed by material such oxidation/reduction agent or acid/alkaline test agent. The polishing pad 60 may comprises more than two indicating strips to determine the lifetime more precisely.

Fig. 7A and Fig. 7B are a top view and a side view of a chemical machanical polisher. The chemical mechanical polisher comprises a polishing platen 70, a holder 71 to hold a wafer to be polished above the polishing platen 70, a belt-type polishing pad 73 on the polishing platen 70, a tube 74 to transport a slurry 75 onto the polishing pad 73, and a pump 76 to pump the slurry to the tube 74. While performing chemical mechanical polishing, the polishing platen 70 and the holder 71 are rotating toward ~~to a~~ certain direction as shown as the arrows 77a and 77b, respectively. The holder 71 presses the wafer in contact with the polishing pad 73. The tube 74 supplies the slurry 75 pumped from the pump 76 onto the polishing pad 73. A chemical reaction thus occurs between the chemical reagent, that is, the slurry 75, and the wafer. With the aid of mechanical polishing, an uneven surface on the wafer is thus planarized.

Fig. 8A shows a polishing platen designed according to the invention. Fig. 8B highlights a part of the polishing platen as shown in Fig. 8A. The lifetime self-indicating polishing pad 80 comprises a main body 81 and a multi-layered colored indicating structure 82. The main body 81 is preferably in a belt type. The colored indicating structure 82 is dyed and inlaid into the main body 81. The material of the colored indicating structure 82 is the same or similar to the material of the polishing pad 80. The colored indicating structure 82 is disposed with a depth L under a top surface of the main body 81. The depth L is typically smaller than the thickness of the polishing pad 80, for example, between 20μm to 500μm. The colored indicating structure 82 may comprise more than one colored indicating layers, such as the colored indicating layers 82a, 82b, and 82c. These colored indicating layers each has a different depth under the top surface of the main body 81, as shown in Fig. 8B.

In Fig. 9A. a polishing platen of a chemical mechanical polisher using the polishing pad shown in Fig. 8A is shown. Fig. 9B is a perspective view of a part of Fig.9A. A polishing pad 90 is placed on the polishing platen. The polishing pad 90 comprises a main body 91 and at least one colored indicating strips 92. The main body 91 has a top surface 93, and the colored indicating strips 92 is laminated under the top surface 93 with a depth of L. The depth L is smaller than a certain value-of thickness. that is, the thickness of the polishing pad 90, for example, 20μm to 500μm. The colored indicating strips 92 may comprise more than one colored layer. for example. 92a. 92b, 92c and 92d, located in difference places of the polishing pad 90 so as to obtain more precise lifetime detection.

By applying the polishing pad comprising a lifetime self-indicating structure to a chemical mechanical polisher, a method for fabricating a shallow trench isolation is shown as Fig. 10A to Fig. 10D. In Fig. 10A, a pad oxide layer 302 with a thickness of about 100Å to 150Å is formed on a substrate 300, preferably, a silicon wafer. A mask layer 304, for example, a silicon nitride layer with a thickness of about 1000Å to 3000Å is formed to cover the pad oxide layer 302. Etching through the mask layer 304, the pad oxide layer 302, and the substrate 300, a trench 306 is formed with a depth between 0.2μm to 0.8μm, preferably, of 0.5μm.

In Fig. 10B, along side walls of the etched trench 306, a liner oxide layer 308 is formed with a thickness ranging from about 150Å to 500Å. An insulation layer 310 is formed to cover the mask layer 304 and to fill the trench 306. Preferably, the insulation layer 310 is formed with a thickness of about 6000Å to 15000Å. Typically, a densification usually follows to obtain an improved the structural quality.